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Three hundred and twelfth meeting.

November 14, 1848. — MONTHLY MEETING.

The PRESIDENT in the chair.

Colonel Graham, of the U. S. Topographical Engineers, gave an account of the labors of the commissioners for running the boundary between the United States and Canada, as established by the Treaty of Washington, and stated that the maps, which were destroyed by fire at Washington when nearly completed, were now in course of reconstruction from the field-notes, &c., copies of which, by direction of the government, were deposited in different places, so as to guard against their destruction by fire, or other casualty.

Professor Webster exhibited remarkably fine specimens of beryl from Royalton, and idocrase from Sanford, near Wells, Maine.

Mr. Desor made some remarks on the retrogression of Niagara Falls, illustrated by plans, and gave reasons for believing that, in their future retrogression, the gradual diminution in the height of the cataract which has been taught by other geologists would not take place.

Professor Lovering read a paper on the causes of the remarkable differences in the strength of ordinary magnets and electro-magnets of the same shape and size, as follows: —

"It is well known that the strength of ordinary magnets does not increase in the same proportion as their weight; but much more slowly. For example, a magnet weighing only three grains has lifted two hundred and fifty times its own weight. A magnet weighing twenty-five grains sometimes lifts forty-five times its own weight. Peschel's new method of magnetizing is considered very efficient, because it will give to a magnet which weighs one pound the power to lift about twenty-six pounds. Magnets of two pounds' weight will rarely lift ten times their own weight. A magnet in the possession of Mr. Peale, of Philadelphia, (the largest natural magnet known,) weighs fifty-two pounds and lifts three hundred and ten pounds; that is, only six times its own weight. These cases are not strictly comparable, because the shape and quality of the iron are not the same in all of them. They indicate, however, with sufficient exactness for my present purpose, that the strength of a magnet, as compared with its weight, is very much less for large magnets than for small ones. It is not difficult to explain this general fact. When one bar of iron is magnetized by another, according to the laws of ordinary magnetic induction, the action is superficial. The most we can do is to bring the surfaces of the two bars into contact on one side. If the mass of iron is thick, the interior portions are so far removed from the inducing magnet, that they receive only a part of the magnetic development of which they are susceptible. This difficulty is removed, if we begin by dividing the thick bar into a number of thin pieces. These may be magnetized separately, and to saturation. When we come to reunite them, we encounter another difficulty. Each piece tends to induce a magnetic state, opposite to its own, in its neighbours ; a state, accordingly, which is opposite to that which its neighbours have already acquired. As soon as the pieces are brought together, a part of the magnetism, originally developed, becomes latent again ; and the united strength of all is not so great as the sum of the powers possessed by the parts when tried separately.

" In 1820, it was discovered that the conducting-wire of a galvanic battery possessed magnetic properties, and was capable of inducing magnetism in a bar of soft iron placed at right angles to its own length. This elementary force, first announced by Arago, was soon multiplied in a wonderful degree by the application of Schweigger's principle to it. At length large masses of iron, which defied the ordinary methods of touch, were magnetized to saturation. Magnets which acquire their magnetism from the induction of electricity (electro-magnets) have been made of such a size and power as to lift ten thousand pounds. Professor Henry gave an account, in *Silliman's Journal*, of an electro-magnet constructed by him, as early as 1831, which, weighing twenty-one pounds, was able to lift seven hundred and fifty pounds ; that is, more than thirty-five times its own weight. I frequently experiment with electro-magnets of a half-pound weight, which lift one hundred and seventy-five times their own weight. With a good current, magnets no heavier than this may be made to lift five hundred times their own weight.

" At the present day, the old statical theory of magnetism has been supplanted by the electro-dynamical theory of Ampere. According to the views of this eminent physicist, all magnets are in one sense electro-magnets. In the electro-magnet properly so called, the inducing currents are obtained from a galvanic battery, and are made to flow through a wire which is wound many times around the iron to be magnetized. Each particle of the iron is supposed to contain, even in its unmagnetic state, currents of electricity, circulating around it. As the direction of these currents is not definite, the particle exhibits no magnetic polarity. As soon, however, as it is exposed to the action of the battery currents, these native currents of the iron assume a direction parallel to one another and to that of the currents in the external wire. When its currents are thus directed, the iron has the properties of a magnet. The magnetism of iron, however developed, consists simply in the magnetic properties of these electrical currents. These currents, moreover, are not created by the inducing agent, but only directed. They are always flowing, but not always in parallel directions. If we take a magnet, in which the currents are already directed, and draw it over a piece of common iron, the currents of the latter are turned round so as to be parallel to those of the former. The only difference between a magnet made in this way, by ordinary touch, as it is called, and an electro-magnet, consists wholly in the source of the inducing and directing currents. In one case, we take them from a battery ; in the other, we use those of a permanent magnet.

" If this be so, the difference which is observed in the strength of an electro-magnet and an ordinary magnet must proceed from a corresponding difference in the inducing currents. The battery currents have a greater magnetizing power than the currents of a well-magnetized bar of steel, either because they are stronger in themselves, or because they act from a more favorable position. Now, I have shown by direct experiment that the currents from the galvanic battery are not in themselves so abundant as those which are flowing around a piece of magnetized steel. We suspend a delicate magnetic needle and oscillate it, first in front of one extremity of a helix, through which a battery current is flowing, and then at the same distance from one pole of a steel magnet. From the rapidity of the oscillations we can easily calculate the relative magnetic forces of the helix and the steel bar. It will be necessary to eliminate that part of the motion which belongs to the earth's influence. This is done by oscillating the same needle, when removed from the action both of the helix and steel bar. From this experiment we learn that the battery currents are not nearly so magnetic, and therefore not so abundant, as those of the steel bar. A helix possesses directive power like a compass-needle, but much feebler than a very weak needle of steel, although the current from a powerful battery flows in the helix. Two helices attract and repel as two magnets; a single helix and a magnet attract and repel as two magnets. In both cases, particularly in the first, the action is much weaker than when we experiment on two magnets. In all the electro-dynamical motions, it is well known that those are the weakest which are produced by the reciprocal action of currents alone, and that a great gain is effected when we substitute for one or both of the currents some kind of iron or steel magnet. Moreover, in electro-dynamical induction, the same superiority appears on the side of the currents of the steel magnets. The currents induced by such magnets are much stronger than those induced by a battery current. When the battery current flows around a piece of soft iron, making it an electro-magnet, then we have the best possible source for induced currents. From all these facts, many of which are familiar, I infer that the battery currents, although possessing a greater magnetizing power than those attached to a steel magnet, are, nevertheless, of less intrinsic energy.

" Whence, then, the question recurs, does this superior efficiency of the weaker currents in imparting magnetism to iron proceed? One cause, without doubt, is the favorable position in which the inducing currents act upon the dispersed currents of the unmagnetic iron. The superficial action of one piece of iron or steel upon another, to which we have already referred, when interpreted by the light of Ampere's theory, amounts to this. The inducing currents of the original magnet and the induced or directed currents of the other bar touch, like any two circles external to one another, only at a single point. If the circulation was around the whole mass of each bar, these circles must still rapidly separate from one another. When we add to this that the flow is about each single particle in each bar, it is obvious that the currents which direct and those which are directed are, for the most part, so remote from one another, and so oblique, as to act at a very great mechanical disadvantage. Moreover, the portions of the circuit which are opposite to the adjacent portions exert a contrary action to that of the latter, and diminish the small result which otherwise might be produced. In electro-magnetizing, the battery current flows wholly round the piece of iron to be magnetized. Throughout the whole circulation, every portion of it is near to at least some part of the iron, so as to act favorably upon it. When we magnetize iron by touch, we can, it is true, turn the different sides up and touch it on all of them. We might even make the original magnet hollow, and insert the bar to be magnetized inside of it, so that all parts should be touched at the same time. Even then the position, as will appear upon reflection, will not be so favorable as where the battery current flows around the bar of soft iron ; inasmuch as two concentric systems of small circles cannot be brought into such close proximity as one system of small circles concentric with a single large circle. We may select an experiment in which these comparatively weak currents from the battery no longer enjoy their favorable position, and then their weakness is plainly manifested. Let a hollow cylinder of iron be taken and placed outside of the helix, instead of inside. In this case, the battery current which flows in the helix, though intrinsically possessing the same magnetic power as before, produces little or no effect on the external iron cylinder.

" Another cause of the superiority of electro-magnets is connected with a peculiarity in the position of the poles of permanent steel magnets. These poles, if the bar has any considerable thickness, are at a little distance inside of the extremities of the magnetic axis. This displacement has been well explained by the interference of contiguous currents in different portions of the thickness of the bar ; their mutual action prevents the planes of motion around the individual particles of iron near the extremities from being strictly parallel to one another, or perpendicular to the magnetic axis. In the electro-magnet, the currents of the iron are maintained in a strictly parallel direction by the controlling and ever-present activity of the battery current, the direction of which is preserved uniform by the rigidity of the wire. Every one knows how rapidly the power of a magnet diminishes with the distance from its pole, and may understand, therefore, how much of force is lost if the pole is inside of the extremity of the bar, and inaccessible. The pole of the electro-magnet is at the extremity of the bar ; we may bring the keeper into actual contact with it ; and for this reason, also, it must appear superior to ordinary magnets. In consequence of this difference in the position of the pole, or the seat of maximum force, the power of the electro-magnet diminishes as the square of the distance from the extremity, while that of the common magnet only diminishes at the same rate as the distance from the extremity increases ; the law being, in both cases, that the force diminishes as the square of the distance from the *pole* increases."